Title 10—DEPARTMENT OF NATURAL RESOURCES
Division 20—Clean Water Commission
Chapter 8—Design Guides

10 CSR 20-8.210 Supplemental Treatment Processes.

*PURPOSE: The following criteria have been prepared as a guide for the design of supplemental treatment processes. This rule is to be used with rules 10 CSR 20-8.110–10 CSR 20-8.[~~220~~]**210** for the planning and design of the complete treatment facility. This rule reflects the minimum requirements of the Missouri Clean Water Commission as regards adequacy of design, submission of plans, approval of plans and approval of completed [~~sewage works~~]**wastewater treatment plant**. **It is not reasonable or practical to include all aspects of design in these standards. The design engineer should obtain appropriate reference materials which include but are not limited to: copies of design manuals such as Water Environment Federation's Manuals of Practice, and other wastewater design manuals containing principles of accepted engineering practice.** Deviation from these minimum requirements will be allowed where sufficient documentation is presented to justify the deviation. These criteria [~~are taken largely from Great Lakes-Upper Mississippi River Board of State Sanitary Engineers Recommended Standards for Sewage Works and~~] are based on the best information presently available **including the Great Lakes-Upper Mississippi River Board of State and Provincial Public Health and Environmental Managers.**. These criteria were originally filed as 10 CSR 20-8.030. It is anticipated that they will be subject to review and revision periodically as additional information and methods appear. Addenda or supplements to this publication will be furnished to consulting engineers and city engineers. If others desire to receive addenda or supplements, please advise the Clean Water Commission so that names can be added to the mailing list.*

Editor's Note: The secretary of state has determined that the publication of this rule in its entirety would be unduly cumbersome or expensive. The entire text of the material referenced has been filed with the secretary of state. This material may be found at the Office of the Secretary of State or at the headquarters of the agency and is available to any interested person at a cost established by state law.

(1) Definitions. Definitions as set forth in the Clean Water Law and 10 CSR 20-2.010 shall apply to those terms when used in this rule, unless the context clearly requires otherwise. Where the terms "shall" and "must" are used, they are to mean a mandatory requirement insofar as approval by the *[~~agency~~]* **Missouri Department of Natural Resource (department)** is concerned, unless justification is presented for deviation from the requirements. Other terms, such as "should", "recommend", "preferred" and the like, indicate *[~~discretionary requirements on the part of the agency and deviations are subject to individual consideration~~]***the preference of the department for consideration by the design engineer.**

(A) Deviations. Deviations from these rules may be approved by the department when engineering justification satisfactory to the department is provided. Justification must substantially demonstrate in writing and through calculations that a variation(s) from the design rules will result in either at least equivalent or improved effectiveness. Deviations are subject to case-by-case review with individual project consideration.

(2) **Applicability. This rule shall apply to all wastewater treatment facilities. This rule shall not apply to animal feeding operations, animal manure management systems or other agricultural waste management systems.** *[~~Exceptions. This rule shall not apply to facilities designed for twenty-two thousand five hundred (22,500) gallons per day (85.4 m³) or less (see 10 CSR 20-8.020 for the requirements for those facilities).~~]*

(3) Post-Aeration. Post-aeration may be required for facilities using chlorine disinfection or having to meet a minimum dissolved oxygen effluent limit in the receiving waterbody. Post-aeration design may involve mechanical aeration, diffused air injection, or cascade type aeration.

(A) Mechanical Aeration. Multiple aeration basins for continuous operability should be provided at all treatment works with a design flow of 50,000 gallons per day or more, unless other means of maintaining an adequate level of dissolved oxygen in the effluent are available.

1. The aeration equipment transfer efficiency shall be determined utilizing the manufacturer's certified rating for the particular equipment being considered. The transfer efficiency shall be adjusted to reflect anticipated field conditions of temperature, atmospheric pressure, initial dissolved oxygen, and composition of the wastewater being oxygenated.
2. When the detention time within the aeration basin exceeds 30 minutes, consideration shall be given to oxygen requirements resulting from biological activity in the postaeration basin.
3. Aeration basins shall be designed to minimize short circuiting of flow and the occurrence of dead spaces. Vortexing shall be prevented.
4. For aeration basins equipped with a single mechanical aeration unit, a minimum of one mechanical aeration unit should be maintained in storage at the treatment works site for immediate installation.

(B) Diffused Air Injection. Multiple aeration basins shall be provided for continuous operability of treatment works having a design flow capacity of 50,000 gallons per day or greater, except where diffusers may be removed from the basin for maintenance.

1. Diffused air aeration systems shall be designed utilizing Fick's Law and the manufacturer's specifications, in the determination of oxygen requirements.
2. When the detention time in the aeration basin exceeds thirty (30) minutes, consideration shall be given to the oxygen requirements resulting from biological activity in the aeration unit. For maximum efficiencies, sufficient detention time shall be provided to allow the air bubbles to rise to the surface of the wastewater prior to discharge from the basin.
3. Diffused aeration basins shall be designed to eliminate short-circuiting and the occurrence of dead spaces
4. Blower design shall be such that with any single unit out of operation, the oxygen requirements will be provided for maintaining effluent dissolved oxygen. A minimum of one standby blower shall be stored at treatment works where single aeration basins are utilized.
5. Supporting experimental data shall be included with the submission of any proposal for the use of diffusers which are considered nonconventional. Such proposals will be evaluated on a case-by-case basis by the department.

(C) Cascade Type Aeration. Effluent aeration may be achieved through a turbulent liquid-air interface established by passing the effluent downstream over either a series of constructed steps, or a rough surface that produces a similar opportunity for transfer of dissolved oxygen to the effluent.

1. The following equations, Equations 210-x and 210-x, shall be used in the design of cascade type aerators:

Equation 210-x

$r^n = (C_s - C_a)/(C_s - C_b)$

where:

r = Deficit ratio

C_s = Dissolved oxygen saturation (mg/l)

C_a = Dissolved oxygen concentration above the weir, assumed to be 0.0 mg/l.

C_b = Dissolved oxygen concentration in the effluent from the last or preceding step

n = The number of equal size steps

Equation 210-x

$r = 1 + (0.11)\,(ab)\,(1 + 0.046\,T)\,(h)$

where:

T = Water temperature (°C)

Commented [ML1]: Fick's Law
$CT = CS + (CO - CS)e^{-KG(A/V)T}$
$KG = 32.2 \times 1.018^{(T-20)}$
Where
CT = Dissolved Oxygen Concentration of effluent at time, T
CS = Dissolved Oxygen Solubility at wastewater temperature,
CO = Dissolved Oxygen Concentration of influent, if unknown use 0.00
KG= Gas Transfer Coefficient
A/V= INTERFACIAL AREA BETWEEN GAS AND LIQUID
T= Time the gas is in contact with liquid

h = Height of one step (ft)
a = 1.0 for effluents
b = 1.0 for free fall and 1.3 for step weirs

2. The equation, Equation 210-x, for determining the number of steps is dependent upon equidistant steps; and, if unequal steps are used, transfer efficiencies must be determined for each separate step.
3. The effluent discharge to a cascade type aerator shall be over a sharp weir to provide for a thin sheet of wastewater. Consideration shall be given to prevention of freezing.
4. The final step of the cascade type aerator shall be above normal stream flow elevation and the cascade aerator shall be protected from erosion damage due to storm water drainage or flood/wave action.
5. When pumping is necessary prior to discharge over the cascade aerator, multiple, variable speed pumps must be provided except when preceded by flow equalization.

(D) Other Methods of Aeration may be utilized and will be evaluated on a case-by-case basis by the department.

(4) Polishing Reactors. Polishing reactors following lagoons and lagoon retrofits are being utilized to further reduce ammonia in the effluent. The reactor can be in a lagoon cell or in a separate basin.

(A) Polishing Reactors.

1. For facultative polishing reactors, the actual liquid depth in a converted lagoon shall not be less than five feet (5') or more than ten feet (10').
   A. The detention time shall not be less than one day nor more than three days, based on design flow.
   B. Post-aeration may be required following facultative polishing reactors to meet effluent dissolved oxygen requirements, due to the depletion of oxygen in facultative reactors. In the summary of design, provide calculations that the dissolved oxygen concentrations meet the water quality standards when using a facultative polishing reactor.
2. The influent line shall discharge below the liquid level of the reactor near the edge of the reactor embankment. The influent line shall enter the reactor at a point opposite the effluent structure to prevent short-circuiting and to provide maximum detention time.
3. The surface loading should not to exceed seven hundred gallons per square foot per day (700 gpd/sq. ft).
4. Sludge should not be present in the polishing reactor; however provisions shall be included to facilitate sludge removal.

(B) Design.

1. Nitrification process sizing shall be less than two tenths a pound TKN per one thousand square feet per day (0.2 lbs TKN/ 1000 sq/ day)
2. The minimum hydraulic retention time shall be three (3) hours.
3. Characteristics of the influent into the reactor shall include a
   A. BOD of 30 mg/L
   B. TSS of 30 mgl/L
   C. Removal of oil, grease, scum, grit and floating debris
5. Biochemical Oxygen Demand loading shall not be more than forty eight pounds per one thousand cubic feet per day (48 lbs BOD/1000 cf/day)
6. Aeration equipment must demonstrate adequate size and capacity based on site-specific conditions and treatment requirements. The air diffusion system shall be designed that aeration piping for the media stack can be isolated without significantly impairing the oxygen transfer capabiliites.
7. Alkalinity. The wastewater must have sufficient alkalinity, a minimum excess of fifty milligrams per liter (50 mg/L) in the effluent or chemical treatment must be included.

8. Temperature. Temperature rates for nitrification shall be adjusted for anticipated wastewater temperatures by the following equation, Equation 210-x.

   Equation 210-x: Ammonia Loading at Temperature, T

   Ammonia Loading at Temperature, T= ammonia loading limit at 20C x (1.058^{T-20})
9. To prevent freezing and to ensure ammonia removal, the design shall include cold weather provisions, including heaters, insulated covers, installation of temperature controlled enclosures for above-ground components.
10. Alarm. A blower malfunction alarm shall be provided. The alarm must be able to notify the operator of alarm activations through telemetry.

(5) Filtration. This section covers tertiary filtration used to remove suspended solids, nutrients, precipitated metals, inorganic ions, or synthetic organic compounds following conventional secondary treatment.

(A) Pretreatment. Conditions requiring pretreatment. Filtration systems shall be preceded with a pretreatment process, such as chemical coagulation and sedimentation or other acceptable process, when:

1. permit requirements for suspended solids are less than 10 mg/l,
2. effluent quality can be expected to fluctuate significantly,
3. significant amounts of algae will be present,

(B) General Design. General design. Filtration shall be accomplished at a uniform rate of one to five gallons per minute per square foot (1-5 gpm/sq ft) of surface area through filter media.

1. Equipment for the application of chemicals to the filter influent shall be provided if necessary, to enhance suspended solids removal and minimize biological growth within the media.
   A. Multiple unit operations for filtration shall be provided to allow for continuous operation and operational variability for a system with an average design of fifty thousand gallons per day (50,000 gpd) or greater.
   B. The operating head loss shall not exceed ninety percent (90%) of the filter media depth.
   C. Each filter shall have a means of individually controlling the filtration rate.
2. The effluent filter walls shall not protrude into the filter media and the incoming flow shall be uniformly applied to flooded media, in such a manner as to prevent media displacement. The height of the filter walls must provide for adequate freeboard above the media surface to prevent overflows.
3. The filter shall be covered by a superstructure if determined necessary under local climatic conditions. There shall be head room or adequate access to permit visual inspection of the operation as necessary for maintenance.
4. Filtration systems shall be designed and constructed with:
   A. Convenient access to all components and the media surface for inspection and maintenance without taking other units out of service; and
   B. Enclosed controls and equipment with heating and ventilation equipment to control humidity.
   C. Filtration systems shall have at least two (2) units with the capacity to handle the maximum wastewater flow with the largest unit out of service.
5. Filters appurtenances . Filters shall be equipped with:
   A. Washwater troughs,
   B. low control for effluent rate,
   C. measurement and positive control of backwash rate,
   D. capability to measure filter head loss,
   E. positive means to shut off flow to filter during backwash,
   F. filter influent and effluent sampling points,
   G. a manual override for automatic controls and each individual valve essential to the filter operation,

H. an underdrain system to uniformly distribute backwash water (and air, if provided) without clogging from solids in the backwash water,

I. a method for periodic chlorination of the filter influent or backwash water to control slime growths, and

J. pressure filters with convenient access to the media for treatment or cleaning.

6. The bottom of a wash water collection trough must be a minimum of six inches (6.0") above the maximum elevation of the expanded media during backwash. A wash water trough must have a minimum freeboard of two inches (2.0") during the maximum backwash flow rate.
7. Back-up power. Filtration systems shall have a back-up power source that meets the requirements of 10 CSR 20-8.140(X).
8. Drain line. Each filter unit shall be equipped with a drain line at least six inches (6") in diameter capable of draining the basin to the headworks.
9. Flocculation. Flocculation shall include:

A. include chemical feed equipment to meet the system's anticipated design flow and the ability to proportion chemical feed rates;

B. ensure the rapid dispersion and mixing of chemicals throughout the wastewater by providing mechanical or in-line static mixers; and

C. include a minimum of two (2) flocculation basins. Each basin shall be equipped with a:

1. method to control the speed of the paddles; and
2. drain line at least six inches (6") in diameter capable of draining it to the head of the plant.

(C) Backwash. Filtration systems shall have the capacity to backwash all filters.

1. A design uniform backwash upflow minimum rate of twenty gallons per square foot per minute (20 gpm/ sq ft), consistent with wastewater temperatures and the specific gravity of the filter media, shall be provided by the underdrain or backwash distribution piping. The backwash rate may be reduced in accordance with the demonstrated capability of other methods, such as air scour, provided for cleaning of filter media.

A. The design backwash flow shall be provided at the required rate by wash water pumps or by gravity backwash supply storage.

B. Two or more backwash pumps shall be provided so that the required backwash flow rate is maintained with largest pump out of service.

C. Duplicate backwash waste pumps, each with a capacity exceeding the design backwash rate by twenty percent (20%), shall be provided as necessary to return backwash to the upstream unit operations.

2. Sufficient backwash flow shall be provided so that the time of backwash is not less than fifteen (15) minutes for treatment works with design flows of one hundred thousand gallons per day (100,000 gpd) or more, at the design rate of wash.

A. A reduced capacity can be provided if it can be demonstrated that a backwash period of less than fifteen minutes can result in a similar clean media bed headloss and a similar filter operating period or run time.

3. The backwash control, or valves, as provided on the main backwash water line, shall be sized so that the design rate of filter backwash is obtained with the control or valve settings for the individual filters approximately in a full open position. A means for air release shall be provided between the backwash pump and the wash water valve.
4. Air scouring, if provided, should maintain three to five cubic feet per minute per square foot (3-5 cfpm/sq ft) of filter area for two (2) to three (3) minutes preceding backwash at the design rate. Water scour system flow rates must be at least 0.5 gpm/sf of media area but not more than 2.0 gpm/sf of media area.
5. The bottom elevation of the channel or top of the weir shall be located above the maximum level of expanded media during back washing. In addition:

A. A backwash withdrawal arrangement for optimizing removal of suspended solids shall be provided.
B. A two-inch (2") filter wall freeboard is to be provided at the maximum depth of backwash flow above the filter media.
C. A level top or edge is required to provide a uniform loading in gpm per foot of channel or weir length.
D. An arrangement of collection channels or weirs to provide uniform withdrawal of the backwash water from across the filter surface shall be provided.

6. Surge tanks, if necessary, shall hold at least 2 backwash volumes.

(D) Deep bed filters. The deep bed filter structure shall provide a minimum depth of eight and half feet (8.5') as measured from the normal operating wastewater surface to the bottom of the underdrain system. The structure should provide for a minimum applied wastewater depth of three feet (3') as measured from the normal operating wastewater surface to the surface of the filter media.

1. Porous plate and strainer bottoms are not recommended. The design of manifold type filtrate collection or underdrain systems shall:
   A. Minimize loss of head in the manifold and baffles.
   B. Assure even distribution of wash water and a uniform rate of filtration over the entire area of the filter.
   C. Provide the ratio of the area of the underdrain orifices to the entire surface area of the filter media at about 0.003.
   D. Provide the total cross-sectional area of the laterals at about twice the area of the final openings.
   E. Provide a manifold which has a minimum cross sectional area that is one and half (1.5) times the total area of the laterals.
2. Surface wash means shall be provided unless other means of media agitation are available during backwash. Disinfected, filtered water or wastewater effluent shall be used as surface wash waters. Revolving type surface washers or an equivalent system shall be provided. All rotary surface wash devices shall be designed with:
   A. Provisions for minimum wash water pressures of forty pounds per square inch (40 psi).
   B. Provisions for adequate surface wash water to provide half to one gallon per minute per square foot (0.5-1.0 gpm/ sq ft) of filter area.
3. Deep bed filters shall be supplied with:
   A. A loss of head gauge.
   B. A rate of flow gauge.
   C. A rate of flow controller of either the direct acting, indirect acting, constant rate, or declining rate types.
   D. If necessary, continuous effluent turbidity monitoring.
   E. A rate of flow indicator on the main backwash water line, located so that it can be easily read by the operator during the backwashing process.

(E). Shallow bed filters. The shallow bed filtration rate should not exceed one and a forth gallons per minute per square foot (1.25 gpm/ sq ft) and shall not exceed two gallons per minute per square foot (2 gpms/ sq ft) of filter area at average design flow.

1. Chlorination prior to shallow bed filtration shall be sufficient to maintain a chlorine residual of one milligram per liter (1 mg/L) through the filter for a system with average design flow of one hundred thousand gallons per day (100,000 gpd) or greater.
2. Multiple unit operations shall be provided to allow for continuous operability and operational variability.
3. The filter media shall consist of a series of up to eight inch filter increments having a minimum total media depth of eleven inches (11"). The sand media shall have an effective size in the range of 0.40 mm to 0.65 mm and a uniformity coefficient of 1.5 or less.

4. Filter inlets shall consist of ports located throughout the length of the filter.
5. The filter underdrainage system shall be provided along the entire length of the filter so that filter effluent is uniformly withdrawn without clogging of the outlet openings provided for collection and backwash.
6. Duplicate backwash pumps, each capable of providing the required backwash flow, shall be provided.
7. Facilities shall be provided for addition of filter aid to strengthen floc prior to filtration.
8. A skimmer shall be provided for each filter.

(F) Pressure filtration. Pressure filter rates shall be consistent with those set forth in gravity filtration. Pressure filter media shall be consistent with that set forth in gravity filtration.

1. For pressure filter operation. The design should provide for:
   A. Pressure gauges on the inlet and outlet pipes of each filter to determine loss of head.
   B. A conveniently located meter or flow indicator with appropriate information to monitor each filter.
   C. The means for filtration and backwashing of each filter individually, using a minimally complex arrangement of piping.
   D. Flow indicators and controls convenient and accessible for operating the control valves while reading the flow indicators.
   E. An air release valve on the highest point of each filter.
2. The top of the wastewater collection channel or weir shall be established at least 18 inches above the surface of the media.
3. An underdrain system to uniformly and efficiently collect filtered wastewater and that distributes the backwash water at a uniform rate, not less than fifteen gallons per minute per square foot (15 gpm/ sq ft) of filter area, shall be provided. A means to observe the wash water during backwashing should be established.
4. Minimum sidewall heights of five feet (5') shall be provided for each filter. A corresponding reduction in sidewall height is acceptable where proprietary bottoms permit reduction of the gravel depth.
5. An accessible manhole should be provided as required to facilitate inspections and repairs.

(G) Traveling bridge. This type of filter is normally equipped with a shallow bed divided into cells with a continuously operated reciprocating cell-by-cell traveling backwash system.

1. Filtration rates. With one cell out of service, the peak application rate to any unit shall not exceed twice the applicable design filtration rate below:
   A. A single media filter shall have a maximum design filtration rate of three gallons per minute per square foot (3.0 gpm/ sq ft) of media surface at the peak hourly flow.
   B. A dual media filter shall have a maximum design filtration rate of four gallons per minute per square foot (4.0 gpm/ sq ft) of media surface at the peak hourly flow.
   C. Backwash system. The backwash system shall:
      1. provide a minimum of twenty gallons per minute per square foot (20 gpm/ sq ft) of media being backwashed at a given time;
      2. have a minimum duration of at least twenty (20) seconds for each compartment;
      3. expand the media a minimum of 20%;
      4. provide a backwash rate, pressure and backwash water storage based on the manufacturer's recommendations; and
      5. have the ability for manual override.
   D. Traveling bridge mechanism. The traveling bridge mechanism shall:
      1. provide support and access to the backwash pumps and equipment;
      2. be constructed of corrosion resistant materials;
      3. have provisions for consistent tracking of the bridge;
      4. provide support of the power cords; and

5. initiate a backwash cycle automatically when a preset head loss through the filter media occurs.

E. Floating material control. A traveling filter system shall provide for automatic and regular removal of any floating material from the surface of a filter and return the floating material to the headworks.

(6) Cloth/Disc Filters.

(A)Cloth or disk filter systems must meet the requirements for Filtration in subsection (5) of this rule.

(B) Media Design.

1. The average pore size of cloth or disk filter media must not exceed thirty (30) microns.
2. The media thickness must be based on the manufacturer's recommendations, considering frequent pressure changes. The manufacturer's recommendations must be included in the Summary of Design.
3. The media must be disinfectant-resistant if the filter will be exposed to disinfectants.
4. The media must be chlorine-resistant if the filter will be exposed to chlorine.

(C) Filtration Rates and Hydraulic Requirements.

1. The design filtration rate must be based on the effective submerged surface area of the media. If the submerged surface area of the media varies based on the operational mode, the design filtration rate must account for the variability.
2. The maximum design filtration rate for peak flow must not exceed six and half gallons per minute per square foot (6.5 gpm/sq ft) of submerged media.
3. The filtration system must be able to treat the design flow rate with one (1) filter unit in backwash mode.
4. The backwash flux rate must be at least six gallons per minute per square foot (6.0 gpm/sq ft) of media, based on the portion of the filter surface that is being actively backwashed.

(D) Disposal of Backwashed Material.

1. Liquid filter backwash must be re-filtered or must be returned to the headworks of the wastewater treatment facility or to the influent lift station.
2. Solid filter backwash material must be pumped to the influent lift station, the headworks, the digester, or to another location approved for processing at least once per day.

(E) Monitoring and Controls.

1. Cloth or disk filters must use an automatic control system.
2. An automatic control system must include manual override capability.
3. Each filter unit must monitor head loss across the unit and must have a head loss gauge or readout.
4. Each filter unit must monitor effluent turbidity and have a turbidity gauge or readout.
5. Gauges and readouts must be readable from the control panel.

(F) Weather Resistance. Cloth or disk filter systems must be protected from the environment. The Summary of Design must describe how the system will be protected from freezing conditions, ultraviolet light, and environmental concerns.

~~*[(4)]*~~(7) High Rate Effluent Filtration.

(A) General.

1. Applicability. Granular media filters may be used as a tertiary treatment device for the removal of residual suspended solids from secondary effluents.~~*[Where effluent suspended solids requirements are less than ten (10) mg/l, where secondary effluent quality can be expected to fluctuate significantly or where filters follow a treatment process where significant amounts of algae will be present, a pretreatment process such as chemical coagulation and sedimentation or other acceptable process should precede the filter units. Pretreatment units shall meet the applicable requirements of section (3) of this rule.]*~~A pre-treatment process such as chemical coagulation, flocculation and sedimentation, or other acceptable process should precede the filter units where

A. **effluent concentrations of less than** ten milligrams (10 mg/L) **of suspended solids and/or 1.0 mg/L of phosphorus must be achieved**;
B. **to obtain adequate turbidity reduction for urban water reuse;**
C. the secondary effluent quality can be expected to fluctuate significantly; or
D . filters follow a treatment process where significant amounts of algae will be present

2. Design consideration. Care should be given in the selection of pumping equipment ahead of filter units to minimize shearing of floc particles. Consideration should be given in the plant design to providing flow equalization facilities to moderate filter influent quality and quantity.

(B) Filter Types. Filters may be of the gravity-type or pressure-type.
1. Pressure filters shall be provided with ready and convenient access to the media for treatment or cleaning.
2. Where greases or similar solids which result in filter plugging are expected, filters should be of the gravity-type.

(C) Filtration Rates.
1. Allowable rates. Filtration rates shall not exceed five *~~[(5)]~~* gallons per minute per square foot **(5gpd/sq ft)** based on the *~~[maximum hydraulic flow]~~* **design peak hourly flow** rate applied to the filter units. **The expected design maximum suspended solids loading to the filter should also be considered in determining the necessary filter area.**
A. With one cell out of service, the peak application rate to any unit shall not exceed twice the applicable design filtration rate below:
1. A single media filter should have a maximum design filtration rate of three gallons per minute per square foot (3.0 gpm/ sq ft) of media surface at the peak hourly flow.
2. A dual media filter should have a maximum design filtration rate of four gallons per minute per square foot (4.0 gpm/ sq ft) of media surface at the peak hourly flow.
2. Number of units. Total filter area shall be provided in two (2) or more units, and the filtration rate shall be calculated on the total available filter area with one (1) unit out-of-service.

(D) Backwash.
1. Backwash rate. The backwash rate shall be adequate to fluidize and expand each media layer a minimum of twenty percent (20%) based on the media selected. **The backwash system shall** provide a backwash rate, pressure and backwash water storage based on the manufacturer's recommendations; and
A. Shall be capable of providing [a] variable backwash rates. *~~[having a maximum of at least twenty (20) gpm/sq. ft. (13.6 l/m²/s) and a minimum backwash period of ten (10) minutes.]~~*
B. Shall have minimum and maximum backwash rates based on demonstrated satisfactory field experience under similar conditions. The backwash system should provide a minimum of twenty gallons per minute per foot (20 gpm/ft) of media being backwashed at a given time.
C. Shall provide for a minimum backwash period of ten (10) minutes.
D. Should have a minimum duration of at least twenty (20) seconds for each compartment.
E. Have the ability for manual override.

~~[(5)]~~(8) Microscreening.
(A) General.
1. Applicability. Microscreening units may be used following a biological treatment process for the removal of residual suspended solids. Selection of this unit process should consider final effluent requirements, the preceding biological treatment process and anticipated consistency

of biological process to provide a high quality effluent.

2. Design considerations. Pilot plant testing on existing secondary effluent is encouraged.
   A. Where pilot studies so indicate, where microscreens follow trickling filters or lagoons, or where effluent suspended solids requirements are less than ten (10) mg/l, a pretreatment process such as chemical coagulation and sedimentation shall be provided.
   B. Care should be taken in the selection of pumping equipment ahead of microscreens to minimize shearing of floc particles.
   C. The process design shall include flow equalization facilities to moderate microscreen influent quality and quantity.

(B) Screen Material. The microfabric shall be a material demonstrated to be durable through long-term performance data. The aperture size must be selected considering required removal efficiencies, normally ranging from twenty to thirty-five (20–35) microns. The use of pilot plant testing for aperture size selection is recommended.

(C) Screening Rate. The screening rate shall be selected to be compatible with available pilot plant test results and selected screen aperture size, but shall not exceed five ~~[(5)]~~ gallons per minute per square foot (5 gpm/sq ft) ~~[(3.40 l/m²/s)]~~ of effective screen area based on the maximum hydraulic flow rate applied to the units.

1 The effective screen area shall be considered the submerged screen surface area less the area of screen blocked by structural supports and fasteners.

2. The screening rate shall be that applied to the units with one (1) unit out-of-service.

(D) Backwash. All waste backwash water generated by the microscreening operation shall be recycled for treatment.

1. The backwash volume and pressure shall be adequate to assure maintenance of fabric cleanliness and flow capacity.
2. Equipment for backwash of at least eight ~~[(8)]~~ gallons per minute per linear foot (8gpm/lf) ~~[(1.66 l/m/s)]~~ of screen length and sixty ~~[(60)]~~ pounds per square inch (60 psi) ~~[(4.22 kgf/cm²)],~~ respectively, shall be provided.
3. Backwash water shall be supplied continuously by multiple pumps, including one (1) standby and should be obtained from microscreened effluent.
4. The rate of return of waste backwash water to treatment units shall be controlled so that the rate does not exceed fifteen percent (15%) of the design average daily flow rate to the treatment plant.
5. The hydraulic and organic load from waste backwash water shall be considered in the overall design of the treatment plant.
6. Where waste backwash water is returned for treatment by pumping, adequate pumping capacity shall be provided with the largest unit out-of-service.
7. Provisions should be made for measuring backwash flow.

(E) Appurtenances. Each microscreen unit shall be provided with automatic drum speed controls with provisions for manual override, a bypass weir with an alarm for use when the screen becomes blinded to prevent excessive head development and means for de-watering the unit for inspection and maintenance.

1. Bypassed flows must be segregated from water used for backwashing.
2. Equipment for control of biological slime growths shall be provided.
3. The use of chlorine should be restricted to those installations where the screen material is not subject to damage by the chlorine.

(F) Reliability. A minimum of two (2) microscreen units shall be provided, each unit being capable of independent operation. A supply of critical spare parts shall be provided and maintained. All units and controls shall be enclosed in a heated and ventilated structure with adequate working space to provide for ease of maintenance.

(9) Ultrafiltration. Ultrafiltration uses a membrane barrier to exclude particles in the range of 10nanomicrons to 1 mimicrons, including bacteria, viruses and colloids. Treatment of feed prior to the membrane is essential to prevent damage to the membrane and minimize the effects of fouling which greatly reduce the efficiency of the separation.

(A) Pre-treatment. Types of pre-treatment are often dependent on the type of feed and its quality, and include pH adjustment and coagulation.

1. Appropriate sequencing of each pre-treatment phase is crucial in preventing damage to subsequent stages. Pre-treatment can even be employed simply using dosing points.
2. The water quality into the ultrafiltration unit is dependent on the type of filtration unit provided (hollow fibre, spiral-wound, or ceramic tubular) and will need to meet the manufacturer's specifications. The range of the design basis for the water quality parameters is provided in Table 210-x.

Table 210-x: Ultrafiltration Water Quality Parameters

Parameter	Units	Design Basis
Turbidity	NTU	<50
Total Organic Carbon	mg/L	<10
Particle Size	Micron	<150
Chemical Oxygen Demand	mg/L	<20
Oil & Grease	mg/L	0
pH	SU	3.0-7.0
Temperature	C	25
Total Suspended Solids	Mg/L	50
Total Dissolved Solids	Mg/L	<500
Iron	Mg/L	<5
Solvents, phenols	Mg/L	<0.1

(B) Design.
(C) Fouling
(D) Operations and Maintenance

(10) Chemical Addition. Wastewater treatment uses chemicals in various forms to aid in sedimentation, nutrient removal, pH adjustment, corrosion and odor control, disinfection, and sludge/biosolids conditioning. Pilot plant studies or data from unit operations treating design flows of wastewater or domestic wastewaters of similar characteristics (organic levels, metal concentrations, etc., within twenty-five percent (25%) of proposed design) shall be required to determine appropriate chemicals and feed ranges. The design shall meet the minimum requirements for Chemical Handling, Housing, Safety, and Identification in 10 CSR 20-8.140(10).

Commented [ML2]: Chemical Addition and Phosphorus removal by chemical treatment has parts that duplicate-should it be combined?

(A) Chemical Selection and Handling. The design shall consider the following for treatment chemicals and document in the summary of design and operations manual:

1. Compatibility with other chemicals being used.
2. Compatibility with other liquids, solids, and air treatment processes (e.g., interference).
3. Provisions for avoiding adverse impacts to effluent, receiving waters, biosolids, or air quality (e.g., interference, inhibition, pass through, accumulation in biosolids).
4. Calculated appropriate design dosage ranges, including laboratory tests (jar tests or pilot-scale studies) on actual process wastewater or operational data from similar facilities.

(B) Chemical Storage. Chemical storage design must provide adequate storage capacity as well as efficient and safe chemical handing. Important factors in determining storage capacity include reliability of the supply, quantity of shipment, the range of chemical use rates, and chemical decomposition during storage. Specifically, the chemical storage design shall include:

1. Space shall be provided where at least thirty (30) days of chemical supply can be stored in dry storage conditions at a location that is convenient for efficient handling, unless local suppliers and conditions indicate that such storage can be reduced without limiting the supply.
2. Compatibility with the chemical type and form (dry, liquid, or gas). Chemicals that are incompatible (i.e., strong oxidants and reductants) shall not be fed, stored or handled in such a manner that intermixing of such compounds could occur during routine treatment operations.
3. Temperature and moisture controls.
4. Safe and easy operator access.
5. Dust control.
6. Containers stored in manner to allow floor level cleanup.
7. Alarms.
   A. High and low level indicators shall be located in tanks and bins.
   B. Leak-detection indicator and alarm for hazardous chemicals.
8. Provisions for continuous feed, if used, including angle of repose and vibrators.
9. Containment. Spill and overflow containment with sufficient volume to hold the contents of the largest tank in the containment area shall be provided.
   A. The ability to access drain valves safely without entering containment area shall be provided.
   B. The liquid chemical storage tank and tank fill connections shall be located within a containment structure.
   C. Valves on discharge lines shall be located adjacent to the storage tank and within the containment structure.
   D. Auxiliary facilities, including pumps and controls, within the containment area shall be located above the highest anticipated liquid level.
   E. Containment areas shall be sloped to a sump area and shall not contain floor drains.
10. Adequate connections and equipment for washing, flushing, and cleanout in chemical storage areas.
11. Pressure/vacuum relief shall be provided on enclosed tanks.
12. For hazardous chemicals, appropriate safety provisions such as eyewash stations, emergency showers, and emergency communication documents. Suitable carts, lifting devices, and other appropriate means shall be provided in accordance with the material safety data sheets and applicable state and federal requirements.
13. Powdered activated carbon shall be stored in an isolated fireproof area, and explosion proof electrical outlets, lights and motors shall be used in all storage and handling areas in accordance with local, state and federal requirements.
14. Acid storage tanks shall be vented to the outside atmosphere, but not through vents in common with day tanks.
15. Floor surfaces shall be smooth but slip resistant, impervious, and well drained with a slope of an eighth inch (1/8') per foot minimum.
16. Concentrated acid solutions or dry powder shall be kept in closed, acid-resistant shipping containers or storage units. Concentrated liquid acids shall not be handled in open vessels, but should be pumped in undiluted form from original containers to the point of treatment or to a covered day or storage tank.

(C) Chemical Handling Design. The design shall provide for safe and efficient unloading, storage, transfer, and use of chemicals in accordance with appropriate codes considering types of chemicals, compatibility, and the amount of handling required. See 10 CSR 20-8.140(10).

1. Features. Provisions shall be made for measuring quantities of chemicals used to prepare feed solutions. Storage tanks, pipelines, and equipment for liquid chemicals shall be specific to the chemicals and not for alternates.

A. Provisions shall be made for the proper transfer of dry chemicals from shipping containers to storage bins or hoppers in such a way as to minimize the quantity of dust that may enter the room in which the equipment is installed. Control shall be provided by use of:
   1. Vacuum pneumatic equipment or closed conveyor systems;
   2. Facilities for emptying shipping containers in special enclosures; or
   3. Exhaust fans and dust filters that put the hoppers or bins under negative pressure in accordance with federal and state requirements.
   2. Provisions shall be made for measuring quantities of chemicals used to prepare feed solutions.
   3. Storage tanks, pipelines, and equipment for liquid chemicals shall be specific to the chemicals and not for alternates.
   4.Liquid chemical storage tanks must:
      A. Have a liquid level indicator.
      B. Have an overflow and a receiving basin or drain capable of receiving accidental spills or overflows.

B. Platforms, stairs, and railings shall be provided as necessary, to afford convenient and safe access to all filling connections, storage tank entries, and measuring devices. Storage tanks shall have reasonable access provided to facilitate cleaning.

C. Above-bottom drawoff from chemical storage or feed tanks shall be provided as necessary to avoid withdrawal of settled solids into the feed system. Provisions for periodic removal of accumulated settled solids must be included. Provisions must be made in the fill lines to prevent back siphonage of chemical tank contents.

D. All liquid chemical mixing and feed installations must be installed on corrosion resistant pedestals and elevated above the highest liquid level anticipated during emergency conditions. The chemical feed equipment shall be designed to meet the maximum dosage requirements for the design conditions.

E. The design must include equipment to measure quantities of chemicals fed from bulk storage and day storage tanks over the range of design application rates. Solution storage or day tanks feeding directly shall have sufficient capacity for twenty-four (24) hour operation at design flow.

F. A minimum of two (2) chemical feeders shall be provided for continuous operability. A standby unit or combination of units of sufficient capacity shall be available to replace the largest unit during shutdowns. 10. The entire feeder system shall be protected against freezing and shall be readily accessible for cleaning.

2. Chemical feeders shall be of such design and capacity to meet the following requirements:
   A. Feeders shall be able to supply, at all times, the necessary amounts of chemicals at an accurate rate throughout the range of feed.
   B. Proportioning of chemical feed to the rate of flow shall be provided where the flow rate is not constant.
   C. Diaphragm or piston type positive displacement type solution feed pumps shall not be used to feed chemical slurries.
   D. The treatment works service potable water supply shall be protected from contamination by chemical solutions or wastewater by providing either an air gap between the portable water supply line and solution tank, or a suitable reduced pressure zone, backflow prevention device, see 10 CSR 20-8.140(8)(D)4.
   E. Chemical-contact materials and surfaces must be resistant to the aggressiveness of the chemical solutions.

3. Solution tank dosing shall provide for uniform strength of solution, consistent with the nature of the chemical solution.

4. Continuous agitation shall be provided to maintain slurries in suspension. The Summary of Design shall include how the facility will achieve rapid and thorough mixing of the wastewater and coagulant(s) in tanks or pipes using:
   A. Inline blenders;
   B. Air mixers;
   C. Mechanical mixers; or
   D. Baffles.
5. A minimum of two (2) flocculation tanks or channels having a combined detention period of between twenty (20) and thirty (30) minutes shall be provided;
   A. Mixing shall be balanced to avoid under-mixing or over mixing such that:
      1. Chemicals are completely dispersed;
      2. Flocculated particles do not settle; and
      3. Flocculated particles are not sheared; and
   B. Independent controls for each tank shall be provided.
   C. A means of dewatering all tanks shall be provided.
6. Chemical feeders should be reasonably adjacent to points of application to minimize length of feed lines.
   A. Chemical feeders shall be readily accessible for servicing, repair and observation.
   B. Chemical feeding equipment shall be provided with containment barriers or protective curbing so that chemicals from equipment failure, spillage or accidental drainage will be contained.
   C. Chemical feed control systems shall provide for both automatic and manual operation including:
      1. Feeders that are automatically controlled should provide for reverting to manual control as necessary.
      2. The feeders shall be capable or being manually started.
      3. Automatic chemical dose or residual analyzers shall be considered and, where provided, should include alarms for critical values and recording charts.
7. Dry chemical feeder systems shall:
   A. Measure the chemical volumetrically or gravimetrically.
   B. Provide effective mixing and solution of the chemical in the solution pot.
   C. Preferably provide gravity feed from solution pots.
   D. Completely enclose chemicals and prevent emission of dust to the operation room.

(D) Chemically Enhanced Sedimentation. The criteria in subsections(A)-(C) shall apply in addition to this subsection for facilities designed for chemically enhanced sedimentation.

1. The design must include low velocities downstream of flocculation, generally less than or equal to half a foot per second (0.5 fps), to avoid sheering the floc.
2. The design must include provisions for increased sludge volume in the tanks, piping, and sludge handling equipment and impacts on digestion.
3. The design must provide multiple coagulant and flocculant injection points in piping or channel before the sedimentation process.
4. Each chemical must be mixed rapidly and uniformly with the flow stream. Where separate mixing basins are provided, they shall be equipped with mechanical mixing devices. The detention period should be at least thirty (30) seconds.
5. The flocculation methods or equipment shall be adjustable in order to obtain optimum floc growth, control deposition of solids, and prevent floc destruction.
6. The velocity through pipes or conduits from flocculation basins to settling basins shall not exceed one and half feet per second (1.5 fps) in order to minimize floc destruction. Entrances to settling basins shall also be designed to minimize floc shear. Settling basin designs shall be in accordance with criteria outlined for the appropriate type of clarifier (i.e., primary, secondary).

7. The design must include automated control of coagulant and flocculant addition with dosing parameters based on design flow.
8. The design must include automated chemical dosing for pH adjustment of effluent to compensate for the potential pH reduction caused by some coagulants and flocculants, if such coagulants and flocculants are proposed or may be used.
9. The design shall address the type and volume of sludge generated. Sludge density and compaction must be considered in chemical sludge pumping designs.

(E) Safety. Gases from feeders, storage, and equipment exhaust shall be conveyed to the outside atmosphere, above grade and remote from air intakes in accordance with applicable state and federal requirements.

1. Special provisions should be made as necessary for ventilation of feed and storage rooms in accordance with state and federal regulations and applicable fire code requirements.
2. For each operator who will handle dry chemicals, protective equipment should be provided, including personal protective equipment for eyes, face, head, and extremities, and protective shields and barriers.
3. Facilities should be provided for eye washing and showering. Protective equipment and neutralizers shall be stored in the operating area.

[~~3~~](11)Phosphorus Removal by Chemical Treatment. Phosphorus Removal by Chemical Treatment.

(A) General.

1. Method. Addition of line or the salts of aluminum or iron may be used for the chemical removal of soluble phosphorus. The phosphorus reacts with the calcium, aluminum or iron ions to form insoluble compounds. These insoluble compounds may be coagulated with or without the addition of a coagulant aid such as polyelectrolyte to facilitate separation by sedimentation **or sedimentation followed by filtration**.
2. Design basis. Laboratory, pilot or full scale trial of various chemical feed systems and treatment processes are recommended for existing plant facilities to determine the **achievable** performance level achievable, cost-effective design criteria and ranges of chemical dosages required. *[~~Systems shall be designed with sufficient flexibility to allow for several operational adjustments in chemical feed point location, chemical feed rates and for feeding alternate chemical compounds.~~]*
3. **The selection of a treatment process and chemical dosage for a new facility should be based on such factors as influent wastewater characteristics, the proposed chemical, effluent requirements, and anticipated treatment efficiency.**
4. **Systems shall be designed with sufficient flexibility to allow for several operational adjustments in chemical feed point location, chemical feed rates and for feeding alternate chemical compounds.**

(B) Process Requirements.

1. Dosage. The **design** chemical dosage *[~~required~~]* shall include the amount needed to react with the phosphorous in the wastewater, the amount required to drive the chemical reaction to the desired state of completion and the amount required due to inefficiencies in mixing or dispersion. Excessive chemical dosage should be avoided.
2. Chemical selection. The choice of lime or the salts of aluminum or iron should be based on the wastewater characteristics and the economics of the total system.
   A. When lime is used it may be necessary to neutralize the high pH prior to subsequent treatment in secondary biological systems or prior to discharge in those flow schemes where lime treatment is the final step in the treatment process.
   B. Problems associated with lime usage, handling, and sludge production and dewatering shall be evaluated and mitigation measures shall be documented in the Summary of Design**.**
3. Chemical feed points. Selection of chemical feed points shall include consideration of the type of chemicals used in the process, necessary reaction times between chemical and

polyelectrolyte additions, and the type of wastewater treatment processes and components utilized. **Flexibility in feed locations shall be provided to optimize chemical usage and overall treatment efficiency.** *~~[Considerable flexibility in feed point location should be provided, and multiple feed points are recommended.]~~*

4. Flash mixing. Each chemical must be mixed rapidly and uniformly with the flow stream.
   A. Where separate mixing basins are provided, they should be equipped with mechanical mixing devices. The detention period should be at least thirty (30) seconds.
   B. When a chemical solution is added on a batch basis to the contents of a secondary cell of a controlled-discharge facultative treatment pond system, a means of adequate dispersal and mixing should be provided, such as an outboard (propeller driven) motorboat.
5. Flocculation. The particle size of the precipitate formed by chemical treatment may be very small. Consideration should be given in the process design to the addition of synthetic polyelectrolytes to aid settling. The flocculation equipment should be adjustable in order to obtain optimum flow growth, control deposition of solids and prevent floc destruction.
6. Liquid—solids separation. The velocity through pipes or conduits from flocculation basins to settling basins should not exceed *~~[1.5]~~* **one and half** feet per second (1.5 fps) *~~[(0.46 m/s)]~~* in order to minimize floc destruction.
   A. Entrance works to settling basins should also be designed to minimize floc shear.
   B. Settling basin design shall be in accordance with criteria *~~[outlined]~~* in 10 CSR 20-8.160.
   C. For the design of a sludge handling system, special consideration should be given to the type and volume of sludge generated in the phosphorus removal process.
7. Filtration. Effluent filtration**, such as with granular media filters or membrane separation technologies**, shall be considered where effluent phosphorus concentrations of less than one milligram per liter (1**mg/L**) *~~[mg/l]~~* must be achieved.

(C) Feed Systems.

1. Location. All liquid chemical mixing and feed installations should be installed in corrosion-resistant pedestals and elevated above the highest liquid level anticipated during emergency conditions.
   A. The chemical feed equipment shall be designed to meet the maximum dosage requirements for the design conditions.
   B. Lime feed equipment should be located so as to minimize the length of slurry conduits.
   C. All slurry conduits shall be accessible for cleaning.
2. Liquid chemical feed system. Liquid chemical feed pumps should be of the positive displacement type with variable feed rate control.
   A. Pumps shall be selected to feed the full range of chemical quantities required for the phosphorus mass loading conditions anticipated with the largest unit out-of-service.
   B. Screens and valves shall be provided on the chemical feed pump suction lines.
   C. An air break or antisiphon device shall be provided where the chemical solution discharges to the transport water stream to prevent an induction effect resulting in overfeed.
   D. Consideration shall be given to providing pacing equipment to optimize chemical feed rates.
   E. Consideration should be given to systems including pumps and piping that will feed either iron or aluminum compounds to provide flexibility.
3. Dry chemical feed system. Each dry chemical feeder shall be equipped with a dissolver which is capable of providing a minimum five (5)-minute retention at the maximum feed rate.
   A. Polyelectrolyte feed installations should be equipped with two (2) solution vessels

and transfer piping for solution makeup and daily operation.

B. Makeup tanks shall be provided with an eductor funnel or other appropriate arrangement for wetting the polymer during the preparation of the stock feed solution.

C. Adequate mixing should be provided by a large diameter, low-speed mixer.

(D) Storage Facilities.

1. Size. Storage facilities shall be sufficient to insure that an adequate supply of the chemical is available at all times. Exact size required will depend on size of shipment, length of delivery time and process requirements. Storage for a minimum of *[~~ten (10)~~]* thirty (30) days' supply *[~~should~~]* shall be provided unless local suppliers and conditions indicate that such storage can be reduced without limiting the supply.

2. Location. The liquid chemical storage tanks and tank fill connections shall be located within a containment structure having a capacity exceeding the total volume of all storage vessels.

A. Valves on discharge lines shall be located adjacent to the storage tank and within the containment structure.

B. Auxiliary facilities, including pumps and controls, within the containment area shall be located above the highest anticipated liquid level.

C. Containment areas shall be sloped to a sump area and shall not contain floor drains.

D. Bag storage should be located near the solution makeup point to avoid unnecessary transportation and housekeeping problems.

3. Accessories. Platforms, ladders and railings should be provided as necessary to afford convenient, safe access to all filling connections, storage tank entries and measuring devices. Storage tanks shall have reasonable access provided to facilitate cleaning.

(E) Other Requirements.

1. Materials. All chemical feed equipment and storage facilities shall be constructed of materials resistant to chemical attack by all chemicals normally used for phosphorous treatment.

2. Temperature/humidity and dust control. Precautions shall be taken to prevent chemical storage tanks and feed lines from reaching temperatures likely to result in freezing or chemical crystallization at the concentrations employed. A heated enclosure or insulation may be required. Consideration should be given to temperature, humidity and dust control in all chemical feed room areas.

3. Cleaning. Consideration shall be given to the accessibility of piping. Piping should be installed with plugged wyes, tees or crosses at changes in direction to facilitate cleaning.

4. Drains and drawoff. Above-bottom drawoff from chemical storage or feed tanks shall be provided to avoid withdrawal of settled solids into the feed system. A bottom drain shall also be installed for periodic removal of accumulated settled solids.

(F) Safety and Hazardous Chemical Handling. **The chemical handling facilities shall meet the appropriate safety and hazardous chemical handling facilities requirements of** 10 CSR 20-8.140(10). [*~~The requirements of 10 CSR 20-8.140(9)(A) shall be met.~~*]

(G) Sludge Handling.

1. General. Consideration shall be given to the type and additional capacity of the sludge handling facilities needed when chemicals are used.

2. De-watering. Design of de-watering systems should be based, where possible, on an analysis of the characteristics of the sludge to be handled. Consideration should be given to the ease of operation, effect of recycle streams generated, production rate, moisture content, de-waterability, final disposal and operating costs.

(12) Carbon Adsorption. Carbon adsorption involves the interphase accumulation or concentration of dissolved substances at a surface or solid-liquid interface by an adsorption process. Activated carbon, which is generally a wood or coal char developed from extreme heat, can be used in powdered form (PAC) or granular form (GAC). Carbon adsorption is used as the polishing process to remove dissolved organic

material remaining in a wastewater treated to a secondary or advanced level. Activated carbon adsorption can also be used for dechlorination.

(A) General.

1. Parameters with general application to design of carbon adsorption units are carbon properties, contact time, hydraulic loading, carbon particle size, pH, temperature and wastewater composition, including concentrations of suspended solids and other pollutants. The design influent characteristics shall be provided in the Summary of Design including suspended solids concentrations (typically <20 mg/L), pH, temperature, flow rate, and expected colloidal material concentrations.
2. The adsorption characteristics of the type of carbon to be used shall be established. Such characteristics may be established using jar test analyses of various activated carbons in reaction with the waste to be treated. Adsorption isotherms for each form of carbon proposed for use shall be determined. The source and availability of replacement carbon, as designed, shall be addressed.
3. Pilot plant studies shall be performed upon the selected carbon using the wastewater to be adsorbed, where industrial and domestic wastes are present to determine: breakpoint, exhaustion rate, contact time to achieve effluent standards; and if applicable, the backwash frequency, pressure drop through the fixed bed columns, and the carbon regeneration capacity required. Where strictly domestic waste is to be treated, data from similar full scale unit operations or pilot plant data will be acceptable.
4. Where carbon regeneration is provided, carbon loss due to transportation between the columns and regeneration furnace in the range of five to ten percent (5-10%) total carbon usage shall be considered normal for design. The rate at which carbon will lose adsorption capacity with each regeneration should be established.
5. If fixed-bed GAC carbon columns must be backwashed to remove solids entrapped in the carbon material, then backwash facilities shall provide for expansion of the bed by at least thirty percent (30%).
6. Consideration should be given also for two units in series for continuous operations. Carbon adsorption unit operations may be provided in parallel or series. Sufficient capacity shall be provided to allow for continuous operability of the carbon adsorption process.
7. Nonfixed bed carbon adsorption unit operations may be operated in the upflow or downflow mode. Duplicate pumping units shall be provided for such unit operations.
8. Carbon adsorption unit operations should provide for purging with chlorine or other oxidants as necessary for odor and bio-mass control.

(B) Design.

1. The minimum height to diameter ratio must be 2:1.
2. The design shall promote aerobic conditions in the filters.
3. The properties and specifications of the activated carbon shall be provided in the Summary of Design. Media depth shall range from a minimum of ten to forty feet (10'-40').
4. Activated carbon filters shall be designed for a flow rate of 4-10 gpm/ based on average daily flow for upflow type filters and 3-5 gpm/sf for down flow type filters
5. Contact time shall at a minimum be fifteen minutes (15 minutes). The normal detention time is fifteen to thirty-five minutes (15-35).
6. The backwash system shall be designed to remove all of the foreign material collected during the filter run. The system shall be designed for a maximum upward flow of 12 to 20 gpm/sf, or a ten to fifty percent (10-50%) bed expansion.

(13) Side-stream Nutrient Removal. Reserved.

(14) Diffusers. Multi-port submerged diffusers can be an acceptable means of ensuring mixing zones will avoid or allow no more than a minor detrimental effect in waters designated as habitat for a threatened or endangered species. A multi-port diffuser consists of a header pipe containing two or more ports (with or without risers) discharging in any orientation and may include wyes and other atypical arrangements.

(A) General Considerations.

1. Computer dilution modeling (e.g. CORMIX) must be provided to justify that water quality standards will be met at the boundaries of acute and chronic mixing zones. The computer dilution models must be calibrated to actual conditions in the field and the analysis must include all critical flow and loading situations expected for the facility, including the low flow conditions on the waterbody.
2. For diffusers being installed at existing facilities, the existing outfall is to remain until the diffuser is installed and the existing outfall is to be removed once the diffuser is installed and operational.
3. The diffuser header length (i.e., first port to last port) shall not be greater than twenty-five percent (25%) of the stream width (or lateral distance corresponding to twenty-five percent (25%) of the cross-sectional area). The mixing zone shall not encroach on a drinking water intake, recreation area, or sensitive habitat, overlap the next downstream outfall, or occlude a downstream tributary.
4. Copies of the Summary of Design, facility plan and design drawings must be submitted to US Fish and Wildlife Service and US Army Corps of Engineers. The system must demonstrate compliance with the requirements of all other regulating agencies. Installation of the diffuser will require notification and an Army Corps of Engineers permit.
5. The Summary of Design shall include a description of construction methods for outfall installation in the water body (e.g., pipeline assembly, trench mechanics, slope stability, access restrictions, mitigation practices, permit requirements) and anticipated required installation permits (e.g., US Army Corps of Engineers)
6. Adequate operation of the diffuser will depend upon development and implementation of a robust inspection and maintenance program for the diffuser. The Operations and Maintenance Manual shall include written inspection and maintenance procedures and schedule to inspect the outfall line and diffuser to document its integrity and continued functioning.
   A. The Operations and Maintenance Manual shall include provisions for operators to remove accumulated material from the diffusers (e.g., manholes, cleanout ports) and to maintain diffuser capacity during low initial operating flows.

(B) Diffuser Design Criteria.

1. The plans shall identify the pipeline from the treatment plant to the receiving waterbody. The pipeline shall be contained within approved property boundaries or easements. A shoreline marker shall identify the specific location of the submerged diffuser.
2. The feeder pipeline and diffuser header shall be located such that the pipeline can be accessed for monitoring and maintenance. Access points to the receiving water should be within close proximity to the diffuser, preferably upstream.
3. The diffusers must be designed to compensate for the geomorphology along the proposed outfall route and diffuser site including stability and mobility of the bottom, anticipated scour and deposition, flood conditions, and other potential hazards to the diffuser (e.g., dredging, recreation or commercial uses, seasonal debris loads).
4. The diffuser pipe and ports shall be constructed of a durable material that will provide a consistent cross section throughout its service life. Ports constructed of carbon steel, stainless steel, and high-density polypropylene have demonstrated suitable service for multi-port diffusers. When carbon steel is used, a coating or corrosion allowance must be provided.
5. The Summary of Design shall document diffuser port size selection and diffuser capability to provide discharge with balanced flow from individual ports at all anticipated effluent flows. The Summary of Design shall document sufficient head is provided to ensure discharge at the peak one hundred (100) year flood elevation with the head loss at peak flow.

6. The diffuser pipe velocity shall be at least two feet per second (2 fps) at peak flows. Individual port velocities shall exceed two feet per second (2 fps) at average dry weather flows. Maximum port velocity shall not exceed fifteen feet per second (15 fps).

(C) Submerged Pipe Design Criteria

1. The Summary of Design and submitted plans shall document provisions to prevent trapped air in the submerged pipes (e.g., pipe profile, air and vacuum release valves, physical anchors).
2. The Summary of Design, plans and specifications submitted must identify how the pipes will properly anchored and armored for expected exposure to scour, debris and high currents during floods.
3. The Summary of Design shall document provisions to control corrosion (e.g., coatings, pipe bonding, sacrificial anodes, impressed current system). Soil electrolytic conditions shall be tested for each application wherever metallic pipe materials are used.

(15) Electrocoagulation. Electrocoagulation is a proven and acceptable means of wastewater treatment, especially with industrial wastewater. However, only limited use has been made of electrocoagulation for domestic or municipal wastewater treatment, both in Missouri and the United States as a whole. Electrocoagulation systems should be evaluated on a case-by-case basis. Design standards, operating data, and experience for this process are not well established. Therefore, design of these systems should be based upon experience at similar full scale installations or thoroughly documented prototype testing with the particular wastewater.

(16) Reverse Osmosis. Reverse Osmosis is a proven and acceptable means of wastewater treatment, especially with industrial wastewater. However, only limited use has been made of reverse osmosis for domestic or municipal wastewater treatment, both in Missouri and the United States as a whole. Reverse Osmosis systems should be evaluated on a case-by-case basis. Design standards, operating data, and experience for this process are not well established. Therefore, design of these systems should be based upon experience at similar full scale installations or thoroughly documented prototype testing with the particular wastewater.

(17) Constructed Wetland.

Commented [ML3]: Opinion on constructed wetlands for the design guides. They work in some areas, but not proven for ammonia removal.